Combustion: tracking O□ and CO□

FizziQ activity · Middle and high school · 45 min

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A tea light burns in a sealed chamber while O_2 and CO_2 sensors log the reaction: FizziQ on smartphone or tablet shows why the flame dies and what combustion yields.

Learning objectives

- Identify the reactants and products of paraffin combustion
- Measure O_2 decrease and CO_2 increase during combustion
- Understand why the candle goes out in a sealed chamber
- Distinguish complete from incomplete combustion
- Connect sensor data to the chemical equation of combustion

Instruments and sensors

CO_2 meter · O_2 meter · SCD40 sensor · O_2 sensor

Materials

- Smartphone or tablet with FizziQ Connect
- SCD40 and O_2 sensors
- M5 Stack module and multiport hub
- Sealed chamber with lid
- Tea light candles
- Note: the protocol remains adaptable to any comparable gas-sensing data acquisition tool.

Protocol

1. Connect the SCD40 and O_2 sensors to the M5 Stack via the multiport hub (red I2C port).
2. If needed, reset the sensors by clicking RESET and confirming. Verify that 4 quantities are displayed: CO_2, temperature, humidity, and O_2.
3. Open FizziQ Connect on your smartphone and connect to the M5 Stack via Bluetooth. Select 'External sensors'.
4. Mount the two sensors inside the sealed chamber, positioning them away from the candle flame (heat and soot can damage sensors).
5. Fix a tea light candle to the bottom of the chamber. Verify that the lid seals properly.
6. Before lighting, note the initial concentrations in ambient air: O_2 (about 20.9%) and CO_2 (about 400-800 ppm). These are your reference values.
7. In FizziQ Connect, set the measurement interval to 250 ms from the M5 Stack menu. The fast rate captures the rapid changes during combustion.
8. Light the candle, then quickly close the chamber lid.
9. Watch the concentrations evolve in real time on the M5 Stack screen or in FizziQ Connect. The candle will eventually go out by itself when O_2 drops too low.
10. Wait 1-2 minutes after extinction for concentrations to stabilize, then stop recording.
11. Export the data in FizziQ Connect: select 'UART Sensor' for O_2, then 'Concentration' for CO_2. Use the 'Share' function to export to a spreadsheet if needed.
12. Analyze the graphs: identify the phases (before lighting, active combustion, extinction, stabilization) and note the initial and final values for O_2 and CO_2.

Expected results

O_2 concentration decreases from 20.9% to about 15-16% at candle extinction. CO_2 increases from 400-800 ppm to about 25,000 ppm. The candle burns for 1-5 minutes depending on the chamber size. Temperature and humidity also increase. The O_2 decrease and CO_2 increase are clearly correlated.

Questions

- Why does the candle go out at about 16% O_2 rather than at 0%?
- What are the products of complete paraffin combustion?
- Why does the flame have a blue base and a yellow top?
- What would happen if you used a larger chamber?
- How does the sealed chamber experiment prove that O_2 is consumed during combustion?
- What is the difference between a physical change and a chemical change?

Going further

- Compare the extinction O_2 concentration for different fuels (candle, ethanol, butane)
- Vary the chamber size and measure how it affects burn time
- Investigate the effect of initial O_2 concentration by flushing with O_2-enriched air
- Use the data to calculate the mass of paraffin consumed
- Compare a short fat candle with a tall thin candle in the same chamber